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QUANTITATIVE VARIATION OF METALLIC ELEMENTS IN WATER SAMPLES BY GF-AAS

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ABSTRACT

50 water samples collected from Bundelkhand region. Water samples were analyzed with the help of Graphite Furnace Atomic Absorption Spectrometry (GFAAS) for 35 metals that concern us because of occupational or residential exposure. Out of 35 metals 23 metals are the heavy elements or "heavy metals" are good for health in small quantities and cause health problem when present in high amount. The result is discussed in term of presence of particular metal.

Key Words: Water, Heavy metals, Graphite Furnace Atomic Absorption Spectrometry (GF-AAS).

Introduction

Water is the most vital element among the other natural resources and it is crucial for the survival of all living organisms, without water. The environment, economic growth and development of our country are all highly influenced by water, its regional and availability and the quality of surface and ground water is highly responsive to the monsoon climate and physiography of the country. The availability also depends on upstream withdrawal for consumptive and non consumptive uses in terms of quality, the surface water of the country is unprotected from untreated industrial effluents and municipal waste water run of pollution from chemical fertilizers , pesticides , oil & libel spillage in the coastal area from the operation of sea & river ports .Water quality from different type of industries ,types of agrochemicals used in agriculture, seasonal water flow and dilution capability by the river system.

The present study has been conducted on 50 water samples collected from Bundelkhand region of India. The samples consist of surface water, deepwater, factory outlets from the Matatila, Orcha, Kalpi and Jhansi.

The collected samples were analyzed with the help of Graphite Furnace Atomic Absorption Spectrometry (GF-AAS). There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or heavy metals ; Antimony, Arsenic, Bismuth, cadmium, Cerium, Chromium, Cobalt, Copper , Gallium, Gold, Iron, Lead, Manganese, Mercury, Nickel, Platinum, Silver, Tellurium, Thallium, Tin, Uranium, Vanadium and Zinc .Interestingly, small amount of these elements are common in our environment and diet and are actually necessary for good health but large amounts of any of them may cause acute or chronic toxicity(poisoning). Heavy metal toxicity can result in damaged or reduced mental and central nervous function, low energy levels and damage to blood composition ,lungs ,kidneys ,liver and other vital organs. Long-term exposure may results in slow progressing in physical, muscular and neurological processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy and multiple sclerosis. Allergies are not uncommon and repeated, long-term with some metals or their compounds may even cause cancer.

For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature. Therefore, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure. In most parts of India, heavy metal toxicity is an uncommon medical condition; however, it is a clinically significant condition when it does occur. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life.

The association of symptoms indicative of acute toxicity is not difficult to recognize because the symptoms are usually severe, rapid in onset, and associated with a known exposure or ingestion:

cramping, nausea, and vomiting; pain; sweating; headache; difficulty in breathing; impaired cognitive, motor, and language skills, mania; and convulsions. The symptoms of toxicity resulting from chronic exposure (impaired cognitive, motor, and language skills; learning difficulties; nervousness and emotional instability; and insomnia, nausea, lethargy, and feeling ill) are also easily recognized; however, they are much more difficult to associate with their cause. Symptoms of chronic exposure are very similar to symptoms of other health conditions and often develop slowly over months or even years. Sometimes the symptoms of chronic exposure actually abate from time to time, leading the person to postpone seeking treatment, thinking the symptoms are related to something else.

Definition of heavy metals

Heavy metals are chemical elements with a specific gravity that is at least five times the specific gravity of water. The specific gravity of water is one at 4 degree C (39degree F). Simply stated, specific gravity is a measure of density of a given amount of solid substance when it is compared to an equal amount of water. Some well known toxic metallic elements with a specific gravity that is 5 or more times that of water are Arsenic, 5.7; cadmium, 8.65; iron, 7.9; lead, 11.34; and Mercury, 13.546.

Beneficial heavy metals

In small quantities, certain heavy metals are nutritionally essential for a healthy life. Some of these are referred to as the trace elements (e.g IRON, COPPER, MANGANESE AND ZINC). These elements or some forms of them are commonly found in foodstuffs, in fruits and vegetables and in commercially available multivitamin products. Diagnostic medical applications include direct injection of Gallium during Radiological procedures, dosing with chromium in parental nutrition mixtures and the use of lead as a radiation shield around x-ray equipments. Heavy metals are also common in industrial applications such as in the manufacture of pesticides, batteries, alloys, and electroplated metal parts, textile dyes, steel and so forth.

Toxic heavy metals

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial or residential setting. Children may develop toxic levels from the normal hand to mouth activity of small children who come in contact with contaminated soil or by actually objects that are food (dirt or paint chips).

Commonly Encountered Heavy Metals

Arsenic

Lead

Mercury

Cadmium

Copper

Arsenic

Arsenic is the most common cause of acute heavy metal poisoning in adults arsenic is released into the environment by the smelting process of copper, zinc, and lead, as well as by the manufacturing of chemicals and glasses. Arsenic gas is a common byproduct produced by the manufacturing of pesticides that contain arsenic. Arsenic may be also be found in water supplies worldwide, leading to exposure of shellfish, cod, and haddock. Other sources are paints, rat poisoning, fungicides, and wood preservatives. Target organs are the blood, kidneys, and central nervous, digestive, and skin systems.

Lead

Lead accounts for most of the cases of pediatric heavy metal poisoning. It is a very soft metal and was used in pipes, drains, and soldering materials for many years. Millions of homes built before 1940 still contain lead (e.g. in painted surfaces), leading to chronic exposure from weathering, flaking, chalking, and dust. Every year, industry produces about 2.5 million tons of lead throughout the world. Most of this lead is used for batteries. The remainder is used for cable coverings, plumbing, ammunition, and fuel additives. Other uses are as paint pigments and in PVC plastics, x-ray shielding, crystal glass production, pencils and pesticides. Target organs are the bones, brain, blood, kidneys and thyroid gland.

Mercury

Mercury is generated naturally in the environment from the degassing of the earth's crust, from volcanic emissions. It exists in three forms: elemental mercury and organic and inorganic mercury. Mining operations, chloral kali plants and paper industries are significant producers of mercury. Atmospheric mercury is dispersed across the globe by winds and returns to the earth in rainfall, accumulation in aquatic food chains and fish in lakes. Mercury compounds were added to paint as a fungicide until 1990. These compounds are now banned; however, old paint supplies and surfaces painted with these old supplies still exist. Mercury continues to be used in thermometers, thermostats and dental amalgam. Medicines, such as mercurochrome and mentholated, are still available. Algaecides and childhood vaccines are also potential sources. Inhalation is the most frequent cause of exposure to mercury. The organic form is readily absorbed in the gastrointestinal tract (90-100%); lesser but still significant amounts of inorganic mercury are absorbed in the gastrointestinal tract (7-15%). Target organs are the brain and kidneys (Roberts 1999).

Cadmium

Cadmium is a by product of mining and smelting of lead and zinc. It is used in nickel cadmium batteries, PVC plastic and paint pigments. It can be found soil because insecticide, fungicides, sludge and commercial fertilizer that used cadmium in agriculture. Cadmium may be found in reservoirs containing shellfish. A cigarette also contains cadmium. Laser non sources of exposure are dental allows electroplating, motor oil and exhaust. Inhalation account for 15-50% of absorption through the respiratory systems; 2-7% of ingested cadmium in absorbed in gastrointestinal system. Target organs are the liver, placenta, kidneys, lungs, brain and bones.

Copper

Copper is an essential micronutrient. The food and nutrient board (FNB) recommends dietary copper intake for adults of 1.5-30 milligrams (mg) per day (NRC 1989). The institute of medicine's (IOM) FNB is reviewing the recommendations. Acute ingestion of excess copper in drinking water can cause gastrointestinal of excess copper in drinking water can cause gastrointestinal (GI) tract disturbances and chronic ingestion can lead to liver toxicity in sensitive populations. In 1991, EPA promulgated an MCLG of 1.3 mg per liter (L) for copper in drinking water to protect against adverse GI tract effects. That value is based on a case study of nurses who consumed an alcoholic beverage that was contaminated with copper. In the study, a dose of 5.3 mg was found to cause GI symptoms. Based on an intake of 2L

Copper is a naturally occurring element that is present in drinking water. Stagnation of water in pipes and plumbing fixtures containing copper and copper alloys in distribution systems and household plumbing allows leaching and increasing water copper levels. Characteristics of the water, including increased acidity, increased temperature, and reduced hardness, can increase the leaching of copper into the water. Acute ingestion of excess copper in drinking water is associated with adverse health effects, including acute gastrointestinal disturbances and chronic ingestion of copper can lead to liver toxicity in sensitive populations. The current EPA MCLG of 1.3 milligrams per liter (mg/l) for copper in drinking water is based on the need to protect against adverse gastrointestinal effects. Some states and municipalities have difficulty maintaining copper levels below the MCLG primarily because of the characteristics.

METHOD AND METERIALS

The present study has been conducted on 50 water samples collected from Bundelkhand region. The samples consist of surface water, deep water, factory outlets from the Matatila, Orcha, Kalpi, and Jhansi.

The collected samples were analyzed with the help of Graphite Furnace Atomic Absorption Spectrometry. There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals": antimony , arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. Interestingly, small's amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chromic toxicity (poisoning).

Instrument used*:* *Graphite Furnace Atomic Absorption Spectrometry*

Description

Graphite furnace atomic absorption (GFAA) spectrometry is a highly sensitive spectroscopic technique that provides excellent detection limits for measuring concentrations of metals in aqueous and solid samples.

Typical Uses

GFAA has been used primarily in the field for the analysis of metals in water. GFAA could be used to determine metals in soil, but the sample preparation for metals in soil is extensive and is not practical for field applications. GFAA cannot be described as a truly field portable instrument. GFAA instruments are extremely sensitive and therefore, must be operated in a clean, climate controlled environment. This can be difficult but not impossible to achieve in a field environment. In addition, the 220-volt electrical power requirement often precludes remote operation. However, GFAA is an example of "taking the laboratory to the field.'' Miniaturization of electronics has significantly reduced instrument size and weight, making it easier to use the instrument in a field laboratory.

Theory of Operation

In atomic absorption (AA) spectrometry, light of a specific wavelength is passed through the atomic vapor of an element of interest, and measurement is made of the attenuation of the intensity of light as a result of absorption. Quantitative analysis by AA depends on: (1) accurate measurement of the intensity of light and (2) the assumption that the radiation absorbed is proportional to atomic concentration.

Samples to be analyzed by AA must be vaporized or atomized, typically by using a flame or graphite furnace. The graphite furnace is an electro thermal atomizer system that can produce temperatures as high as 3,000 degree Celsius. The heated graphite furnace provides the thermal energy to break chemical bonds within the sample and produce free ground-state atoms. Ground-state atoms then are capable of absorbing energy, in the form of light, and are elevated to an excited state. The amount of light energy absorbed increases as the concentration of the selected element increases.

GFAA has been used primarily for analysis of low concentrations of metals in samples of water. GFAA can be used to determine concentrations of metals in soil, but the sample preparation for metals in soil is somewhat extensive and may require the use of a mobile laboratory. The more sophisticated GFAAS have a number of lamps and therefore are capable of simultaneous and automatic determinations for more than one element.

Logistical needs include reagents for preparation and analysis of samples, matrix modifiers, a cooling system, and a 220-volt source of electricity. In addition, many analytical components of GFAA system require significant space, which typically is provided by a mobile laboratory. A tabletop GFAA spectrometer and data processor are pictured above.

System Components

GFAA spectrometry instruments have the following basic features: 1. a source of light (lamp) that emits resonance line radiation; 2. An atomization chamber (graphite tube) in which the sample is vaporized; 3.a monochromatic for selecting only one of the characteristic wavelengths (visible or ultraviolet) of the element of interest; 4.a detector, generally a photomultiplier tube (light detector that are useful in low intensity application), that measures the amount of absorption; 5.a signal processor- computer system (strip chart recorder, digital display, meter, or printer.

Mode of operation

Most currently available GFAAs are fully controlled from a personal computer that has Windows-Compatible software. Aqueous samples should be acidified (typically with nitric acid) to pH of 2.0 or less. Discoloration in a sample may indicate that metals are present in the sample.

For example, a greenish color may indicate a high copper content. A good rule to follow is to analyze clear samples first, and then analyze colored samples. It may be necessary to dilute highly colored samples before they are analyzed.

After the instrument has warmed up and been calibrated, a small aliquot (usually less than 100 micro liters and typically 20 micro liters is placed, either manually or through an automated sampler, into the opening in graphite tube; the amount of light energy absorbed in the vapor is proportional to atomic concentrations. Analysis of each sample takes from 1 to 5minutes, and the results for a sample are the average of triplicate analysis.

Graphite tubes must be changed after every 200 to 800 burns because they become pitted and produce data that are only poorly reproducible, and results in a loss of sensitivity. The sample must be dilute if the absorbance is outside the calibration range. GFAA has a smaller linear concentration range than flame AA or inductively coupled plasma (ICP) spectrometry.

Performance Specs

Performance specs include information on interferences, detected limits, calibration, sample preparation, quality control, and precision and accuracy.

Interferences

The GFAA technique is subject to chemical, spectral, and ionization interferences. The composition of the sample matrix typically has the largest effect on the results of the analysis. Chemical interferences occur when the atoms are not completely free or in their ground state. Spectral interferences occur when atomic or molecular species other than the element being analyzed absorb energy at the wavelength of interest. Ionization interferences occur when the furnace causes complete removal of electrons from an atom, thereby lowering the concentration of ground state atoms available to absorb light.

A serial dilution technique may be used to help verify the absence of chemical and spectral interference. In cases in which interference is suspected, samples should be treated in one or more of the following ways: (1) samples should be diluted and reanalyzed successively to determine whether the interference can be eliminated or not, (2)matrix modifiers should be added, or (3)the samples should be analyzed by the method of standard additions. It is common practice to add matrix modifiers to all samples to compensate for potential chemical and spectral interferences.

Detection Limits

Numerous metals can be analyzed by GFAA, as long as their atoms can be vaporized in the graphite furnace. Such elements include aluminum, arsenic, barium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silicon, silver, sodium, titanium, terbium, vanadium, ytterbium, and zinc. Click to view a table showing the detection limits of the metals listed above. Detection limits can be very low with GFAA analyses (below most of the maximum containment levels (MCL) for drinking water established by the U.S. Environmental Protection Agency (EPA) and usually are 10 to 100 times lower than the detection limits for analyses by flame AA or ICP for the same element.

Calibration

Continued calibration of the instrument is a component of overall quality control plan and should be performed by analyzing one mid-concentration standard after every 10 analyses. The relative percent difference (RPD) between the initial calibration and the continuing calibration should be less than 15 percent.

Sample Preparation

Samples are analyzed in triplicate, but it only takes about 5 minutes for sample analysis. Water samples should be acidified with nitric acid to a Ph of less than 2. If dissolved metals analysis is required, the water samples should be filtered through a 0.45 micrometer filter. If the water samples are very turbid, they should be centrifuged prior to analysis or allowed to settle. To alleviate interferences, matrix modifiers should be added. The water samples have a holding time 6 months after they are preserved. In the field, most water samples are analyzed within a few hours.

Quality Control

Method blanks are analyzed with each batch of 20 samples analyzed. Method blanks monitor laboratory-induced contaminants or interferences. A method blank must not contain any remain of analyzed in a concentration higher than the practical quantization limit.

Matrix spike (MS) and matrix spike duplicate (MSD) samples are analyzed to evaluate the efficiency of the sample preparation, matrix effect, and the precision of the analysis. MS-MSDs are prepared with each batch of 20 samples. The advisory control limit range for spike recovery is 50 to 150 percent. The advisory control limit for RPD in water samples is 25 percent.

Laboratory control samples (LCS) are used to evaluate the accuracy of the analysis. The LCSs are obtained from outside sources and contain known amounts of metals. The values obtained by analysis of the LCSs are compared with known true values. The supplier of the LCSs usually provides control limits. The results obtained should fall within the published range of acceptance values. When no control limits are provided, a range of 50 to 150 percent should be used.

Precision and Accuracy

Contamination of samples can be a major source of analytical error because of the extremely low detection limits achieved with GFAA spectrometry. The work area used for sample preparation must be kept clean. That requirement is particularly important in a mobile field laboratory, where it is easy for airborne dust to contaminate the analytical equipment and glassware.

Other Standard Analytical Practices Include

Use of pre-cleaned glassware or washing of the glass in acid

Use of trace-metal-grade distilled, de-ionized water and nitric acid

Prevention of accumulation of dust in the auto sampler cups

Advantages

The advantages of GFAA spectrometry include:

Greater sensitivity and detection limits than other methods

Direct analysis of some types of liquid samples

Low spectral interference

Very small sample size

Limitations

The limitations of GFAA spectrometry include:

Longer analysis time than AA or ICP analysis

Limited dynamic range

High matrix interference

No true field portability with a mobile laboratory setup usually required

220-volt power source required

RESUTS AND DISCUSSION

In the present study total of 50 water samples were collected from various water resources of Bundelkhand Region and analyzed for various heavy metals- Arsenic, copper, mercury, lead and cadmium. Results are shown in tables. The following results have been drawn.

Arsenic: Out of the 50 samples, 30 samples didn't show any presence of Arsenic and out of 20 samples, which contain arsenic, it was found that quantity of Arsenic varied from 0.1 to 8.1 microgram/liter.

Copper: Out of the 50 samples, 12 samples didn't show any presence of copper and out of 38 samples, which contain copper, it was found that quantity of copper varied from 0.7 to 177.3 microgram/liter.

Mercury: Out of the 50 samples, 3 mercury amples didn't show any presence of m and out of 47 samples, which contain mercury, it was found that quantity of mercury varied from 0.4 to 140.1 microgram/liter.

S.No.	**Location**	**Date**	**Time**	**As (mg/L)**	**Cu (mg/L)**	**Hg (mg/L)**	**Pb (mg/L)**	**Cd (mg/L)**

Lead: Out of the 50 samples, 50 samples didn’t show any presence of lead and out of 32 samples, which contain lead, it was found that quantity of lead varied from 0.2 to 62.7 microgram/liter.

Cadmium: Out of the 50 samples, 48 samples didn’t show any presence of cadmium and out of 2 samples, which contain cadmium; it was found that quantity of cadmium varied from 0.4 to 34.4 microgram/liter.

Surface Water:

Arsenic: in the surface water quantity of Arsenic varied from 0.3 to 1.7 microgam/liter.

Copper: in the surface water quantity of copper varied from 3.2 to 152.4 microgam/liter.

Mercury: in the surface water quantity of Hg varied from 1.1 to 100.5 microgam/liter.

Lead: in the surface water quantity of lead varied from 3.1 to 42.7 microgam/liter.

Cd: in the surface water quantity of Cd varied from 0.4 to 34.4 microgam/liter.

Ground Water:

Arsenic: in the ground water quantity of Arsenic varied from 0.2 to 1.8 microgam/liter.

Copper: in the ground water quantity of copper varied from 0.7 to 20.6 microgam/liter.

Mercury: in the ground water quantity of mercury varied from 0.5 to 140.1 microgam/liter.

Lead: in the ground water quantity of Arsenic lead from 0.2 to 39.3 microgam/liter.

Cd: in the ground water quantity of cadmium was absent.

Table 1: Surface water

S.	Location	Date	Time	As	Cu	Hg	Pb	Cd
1.	Laxmi Kund Shahar Jhansi	10/02/2007	08:50 am	0.9	152.4	100.5	42.7	0.0
2.	Laxmi Tal Jhansi	10/02/2007	09:00 am	0.0	0.0	72.2	24.2	0.0
3.	Pahuj River Lakara Jhansi	13/02/2007	12:10 pm	0.0	21.8	6.6	14.0	0.0
4.	Pahuj dam IGFRI Jhansi	13/02/2007	01:20 pm	0.0	12.8	7.6	9.0	0.0
5.	Matatila Dam Lalitpur	05/01/2007	10:50 am	1.7	14.3	0.0	10.0	34.4
6.	Shahjad Dam Lalitpur	05/02/2007	11:25 am	0.0	76.0	0.4	5.0	0.4
7.	Talbehat ka Talab	05/01/2007	11:40 am	0.3	9.2	5.2	12.1	0.0
8.	Rajghat Canal Lalitpur	o5/01/2007	10:25 am	0.3	15.0	1.3	9.4	0.0
9.	Meran ka Talab Tajbehat	05/01/2007	05:50 pm	0.0	13.1	8.3	6.7	0.0
10.	Matatila Canal Babina	07/02/2007	10:45 am	0.0	17.9	9.1	3.1	0.0
11.	Betwa Canal Badaganv Jhansi	11/02/2007	02:00 pm	0.0	3.2	1.1	28.1	0.0
12.	Pareechha Dam	11/02/2007	12:30 pm	1.3	0.0	16.1	12.4	0.0
13.	Betwa River Orchha	25/01/2007	11:00 am	0.0	40.9	12.7	6.2	0.0
14.	Yamuna River Kalpi Jajaun	28/02/2007	01:00 pm	1.6	0.0	47.0	4.4	0.0
15.	Talab Orai Jalaum	28/02/2007	03:00 pm	1.7	0.0	49.2	0.0	0.0

No.				**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**	**(mg/L)**
16.	Handpump Medical College Jhansi	05/02/2007	07:10 am	0.0	0.0	4.0	2.5	0.0
17.	Handpump Pareecha	11/02/2007	01:10 pm	0.0	20.6	140.1	11.6	0.0
18.	Handpump Badaganv Jhansi	11/02/2007	02:30 pm	0.0	0.0	64.1	5.5	0.0
19.	Handpump Friends Colony Jhansi	22/01/2007	03:30 pm	0.0	20.1	27.9	0.0	0.0
20.	Handpump Badapul Jhansi	22/01/2007	02:30 pm	0.8	0.0	18.6	0.0	0.0
21.	Handpump Railway Crossing Jhansi	22/01/2007	02:00 pm	0.0	4.0	0.0	0.0	0.0
22.	Handpump Ritubihar Jhansi	22/01/2007	03:00 pm	0.0	1.2	3.9	0.0	0.0
23.	Handpump Pathoria Jhansi	22/01/2007	04:00 pm	0.2	0.0	12.7	0.0	0.0
24.	Handpump Palcolony Jhansi	20/02/2007	01:30 pm	0.6	8.3	18.3	0.0	0.0
25.	Well Swamipuram Jhansi	14/02/2007	11:00 am	0.0	0.0	10.4	0.2	0.0
26.	Handpump Swaraj Tractors Jhansi	14/02/2007	11:30 am	0.0	2.9	26.2	0.0	0.0
27.	Well Home-Guard Jhansi	14/02/2007	12:00 pm	0.0	6.6	5.3	12.8	0.0
28.	Well Pathoria Jhansi	14/02/2007	01:00 pm	1.8	0.0	38.7	0.0	0.0
29.	Well I.G.F.R.I. Jhansi	14/02/2007	03:00 pm	0.6	10.0	14.6	0.0	0.0
30.	Well Nrcf Jhansi	14/02/2007	03:30 pm	0.0	2.2	0.5	2.3	0.0
31.	Well Lakara Jhansi	14/02/2007	04:00 pm	0.5	0.0	13.2	1.7	0.0
32.	Well Buda Ganv Jhansi	14/02/2007	04:30 pm	0.0	2.9	0.0	0.0	0.0
33.	Well Bhojla Jhansi	14/02/2007	04:30 pm	0.0	5.9	19.8	0.0	0.0

34.	Well D.A.V Pathoria Jhansi	14/02/2007	12:30 pm	0.0	0.7	25.5	39.3	0.0

Table 2: Ground Water

S. No.	Location	Date	Time	As (mg/L)	Cu (mg/L)	Hg (mg/L)	Pb (mg/L)	Cd (mg/L)

Table 3: Factory Outlets

35.	Nala Pareechha Jhansi	02/11/2007	01:50 pm	8.1	64.7	0.9	0.0	0.0
36.	Wagan Repair Workshop Jhansi	15/01/2007	02:00 pm	3.6	32.0	9.8	27.5	0.0
37.	CWM Workshop Railway Jhansi	15/01/2007	03:00 pm	2.5	47.0	15.9	26.4	0.0
38.	JMK Motors Workshop Jhansi	17/02/2007	02:00 pm	0.0	42.3	60.8	14.5	0.0
39.	Plastic Sheet Factory Jhansi	17/02/2007	02:30 pm	0.0	14.3	3.7	16.1	0.0
40.	Hankul Packbell Plastic Factory	18/02/2007	03:00 pm	0.0	0.0	4.2	0.0	0.0
41.	Plastic Bag Factory Jhansi	19/02/2007	02:00 pm	0.0	56.3	3.9	0.0	0.0
42.	Amar Ujala Press Jhansi	20/02/2007	01:00 pm	0.0	177.3	47.6	62.7	0.0
43.	Dainik Jagan Press Jhansi	20/02/2007	02:00 pm	0.0	130.6	50.9	49.8	0.0
44.	Wagan Repair Workshop Jhansi	21/02/2007	10:30 am	1.7	37.4	40.2	0.0	0.0
45.	CMW Workshop Railway Jhansi	21/02/2007	11:30 am	0.0	45.3	37.8	0.0	0.0
46.	JMK Motors Workshop Jhansi	22/02/2007	11:00 am	0.0	46.5	29.8	0.0	0.0
47.	Plastic Sheet Factory Jhansi	22/02/2007	12:30 pm	0.1	15.0	6.8	7.4	0.0
48.	Amar Ujala Press Jhansi	23/02/2007	03:00 pm	1.7	140.0	50.0	48.6	0.0
49.	Dainik Jagan Press Jhansi	23/02/2007	04:00 pm	0.0	136.0	48.8	42.0	0.0
50.	Plastic Bag Factory Jhansi	24/02/2007	10:30 am	0.2	54.2	6.6	4.7	0.0

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